ANALYSIS ON THE IMPLEMENTATION EFFECT OF PROMOTING ACTIVE LEARNING WITH PROJECT-BASED LEARNING

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ABSTRACT

Background

Given today's information deluge and the swift strides in artificial intelligence, foundational knowledge is readily accessible online. The willingness to take the initiative to learn is obviously more important. At present, project-based learning is widely promoted in the world, and China is no exception, and since 2016, Zhejiang, China, has promoted STEAM education as a promotion curriculum integration. An important starting point for transforming the way you learn. Although project-based learning is widely carried out, there is a lack of quantitative research on the effective organization and implementation of project-based learning and the corresponding learning effects.Educators build and provide learners with supportive learning resources and tailor guiding issues of project-based learning to provide a path to transition from traditional direct teaching to a project-based active learning approach that encourages students to be proactive and seek resources as needed.

Objectives

This study will use the database design curriculum as an example to implement project-based learning, build project-based learning elements, and record students' learning activity data in project-based learning activities, which has 45 students in a junior college in Zhejiang in 2023.

Methods

The study collected data from learning platforms that included various supportive learning resources, including the number of online discussions, the number of tasks completed, video watch time data, chapter learning repetition, the distribution and trend of chapter learning time, teacher surveys, and face-to-face discussions and offline unsupervised learning.

Results and Conclusions

This lab takes database project-based learning as an example and evaluates whether learners can gain real-world practical experience in new learning methods. The analysis of project-based learning outcomes shows that the project-based active learning method enhances students' awareness of the importance of database design, cultivates enthusiasm, and promotes active learning in learning, better cultivate students who can navigate beyond basic knowledge points to embrace multidimensional inventive learning. Experimental data shows that strong positive correlation between high-quality project-based learning and student enthusiasm.

DOI:10.5121/ije.2024.12205

KEYWORDS

Project-Based Learning; Supportive Learning Resources; Guiding Issues of Project-Based Learning; Effect Size; Learning Effect.

1. INTRODUCTION

Berman believes that "project learning is an activity that allows students to create, verify, improve, and create something" [1] (Sally Berman, 2004). In the context of " project-based learning using databases as an example ", students confront authentic database design challenges, formulate questions rooted in real-world scenarios, and undergo learning through problem-solving in the design phase. This method promotes problem-solving via a blend of individual practice and collaborative interaction. With a comprehensive inquiry approach, involving intricate real-world problems and meticulously crafted tasks, students immerse themselves in the acquisition of database knowledge and skills. The caliber of database design has a direct bearing on the quality of data governance within the database management system. Given that database technology is intrinsically hands-on, delving into practical, project-based learning using databases as an example facilitates students' engagement in practical application discovery, fosters the formulation of database construction concepts, and cultivates profound learning during the database design and creation stages.

Yet, the question arises: Is project-based learning using databases as an example truly efficacious? Currently, there is a noticeable gap in quantitative studies on the effectiveness of project-based learning in China. Student enhancements and achievements in database design can be attributed to myriad factors. What are the genuine elements that markedly augment learning outcomes and foster authentic learning?

When juxtaposing project-based learning with conventional pedagogical techniques, is there a noticeable uptick in students' zeal for grasping database technology? Do students exhibit a more expansive thought process and approach when faced with challenges? Does project-based learning bolster students' capabilities in transferring and resolving hands-on issues? To elucidate these queries, a well-structured experiment is imperative, aiming to delineate the requisite support for future curricula grounded in project-based learning.

2. PROJECT-BASED LEARNING ELEMENTS OF DATABASE DESIGN

The essence of project-based learning using databases as an example revolves around "self-directed learning" and "personalized learning". This learning paradigm confronts students with tangible tasks, compelling them to independently forge solutions. Within this learning framework, participants autonomously gather database information, assimilate core database knowledge, decipher user requirements through iterative interpersonal engagements, and actively design and deploy standardized databases.

Active learning through project-based learning incorporates several elements: learning objectives, auxiliary learning resources, guiding questions, project-oriented tasks, and process evaluations [2] (Zhan Ying, 2022).

In this methodology, educators establish learning aims anchored. They then curate and dispense an array of supportive learning resources, spanning conventional textbooks, expansive online learning networks, and authentic database user requirements scenarios. Notably, the online learning ecosystem comprises micro-video compilations, benchmark database samples, and platforms dedicated to online research and collaborative learning. Predicated upon the user scenarios chosen by the students, educators allocate segmented tasks for each phase of the tailored database design, frame guiding questions, and allow students to spearhead the database design trajectory. This dynamic is enhanced by educator-student interactions and evaluations of the design's progress from both clients and instructors. Given the individualized nature of learning, diverse learners may receive varying feedback based on their distinct outcomes. Should the interim evaluations reveal areas for potential enhancement, students are empowered to selectively delve into pertinent support resources. Through continuous guidance and probing questions, students gradually assimilate the rigorous standards inherent in database design, cultivating the dexterity to apply knowledge to real-world challenges. This project-centric learning model metamorphoses the erstwhile unilateral instructional approach into a more dynamic one. Here, students tailor their learning journey by cherry-picking resources that align with their design progress, specific project themes, and evaluation feedback. This shift fosters a more student-led learning experience, ensuring genuine and profound comprehension. The interplay between various components in the project-based learning using databases as an example blueprint is depicted in Figure 1. Pupils leverage these supplementary resources to fulfill tasks related to database creation and maintenance. Instructors' guidance, while implicit, remains instrumental in curating these resources. And, whenever students find themselves in need of technical insights, prompt feedback is rendered, nudging learners towards their objectives through iterative evaluation cycles.

The supportive learning resources feature exemplary database models, micro-video compilations elucidating these models, sequentially organized subtasks possessing inherent logic, and a curated set of guiding questions tailored for each subtask. As students navigate through these structured task lists, they progressively cultivate an inherent understanding. When striving to accomplish the objectives of project-based learning tasks, students nurture a transferable thought process, evolve to independently reason, spark innovative higher-order cognition, and ultimately achieve their learning goals.

To realize these learning objectives, students adhere to the foundational thread of project-based tasks, addressing real-world challenges and engaging in sustained learning pursuits. The learning assignments, paired with project-based tasks within the supportive resources, synchronize in a cyclical, mutually reinforcing manner, propelling the consistent exploration and assimilation of knowledge.

During project-based learning, should students grapple with challenges or dilemmas, the provided resources offer viable solutions. Beyond conventional teaching tools, these supplementary resources curate illustrative "tasks" on digital platforms, structured akin to course directories. This "chain" is readily accessible, allowing students the autonomy to revisit and engage with content at their discretion. This empowers them, sparking inspiration, urging them to pivot their thought processes, and subsequently craft their unique solutions.

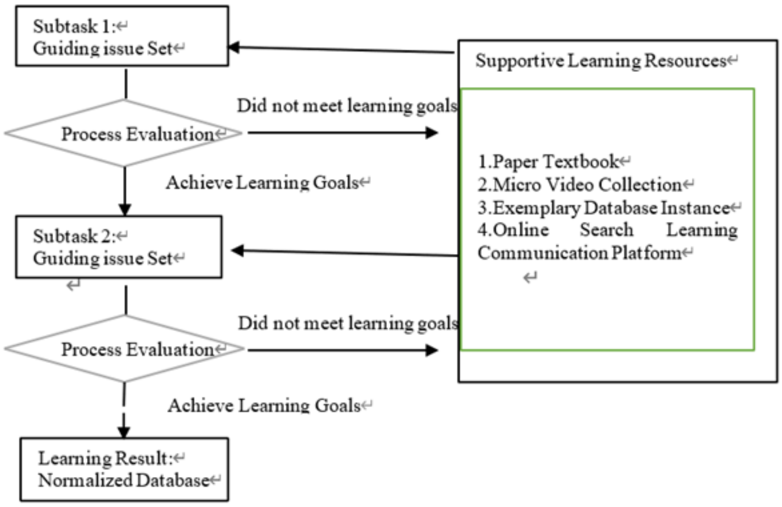

Figure 1. The relationship diagram of each practical element included in the project-based learning design using databases as an example.

3. DESIGN OF PROJECT-BASED LEARNING TASKS

Xia Xuemei believes: "The design of project-based learning is inseparable from the exploration of the concept of knowledge, and it is the reconstruction and creation of the core knowledge of the subject in the context [3] (Xia Xuemei, 2018). When crafting project-based learning tasks, primary attention is accorded to the core project learning task chain and the subsequent process of project learning activities. The former delineates the sequence of subtasks that students must navigate, driven by guiding questions, necessitating persistent exploration. The latter depicts the student's engagement with supportive learning resources while accomplishing project-based tasks. It encompasses the application, completion of each subtask, peer-assessment or evaluations from educators and clients, and iterative refinement of tasks based on these evaluations.

Emphasizing the nexus between curriculum study and real-world contexts [4] (Zhang Feng et al., 2022), Xia Xuemei believes: "For teachers, the Chinese construction of project-based learning means that in the learning situation, they can flexibly choose the appropriate project type and design for themselves. Real problems that are meaningful to students" [5] (Xia Xue Mei, 2020). Consequently, tasks associated with database design in project-based learning should be concise yet flexible, granting students the liberty to independently chart their course. Possible avenues include the design of a tea traceability system database, graduation thesis topics, database design of management systems, or the formulation and upkeep of a "factory material management" database for material management systems [6] (Zhan Ying et al., 2022).

4. DESIGN OF GUIDING ISSUES

Effectively integrating practical guiding problems is fundamental to project-based learning. By consistently posing guiding issues, students are encouraged to delve deeper into database design project learning, igniting their curiosity to explore database knowledge and engage in immersive thinking. These questions not only generate solution pathways but also invigorate discussions, inquiries, and investigations, motivating students to take an active role in database practices. Such questions should be woven throughout the entirety of the project learning process. Their presence not only structures and propels the progression of project learning activities but also ensures that a range of tasks and activities maintain internal coherence.

How should one formulate driven issues pertaining to database design? Which questions will effectively spur students into proactive thinking?

4.1. Guiding Issues should be Designed Around Real Project Topics

Guiding issues should possess a genuine authenticity, anchoring them to real-world scenarios. By grounding these questions in tangible database design projects drawn from everyday life, students are introduced to project-based learning. The end results are functional databases tailored to address real-world challenges. When these databases meet the needs of users and garner approval from clients, students not only experience a heightened sense of achievement but also develop a more profound interest in database technology.

Take, for instance, the design of a "factory material management" database. This sizable project, rooted in practical application scenarios, offers students invaluable guidance throughout the project learning journey.

4.2. The Guiding Issues should be a Key Question that can Trigger Students' Independent Exploration and Promote Students' Problem Solving

Guiding issues should guide students in their analytical and decision-making processes, foster self-awareness, and aid in the construction of a structured database knowledge system. Over time, these questions serve as a foundation for cultivating a problem-solving methodology. For instance, a teacher might prompt students with the following thought process:

In undertaking the extensive project of designing database, into which distinct tasks should the project be segmented?

Database design can be delineated into six interconnected tasks: requirement analysis, conceptual structure design, logical structure design, database physical design, database implementation, and database operation and maintenance [2] (Zhan Ying et al., 2022). Collectively, these tasks form a cohesive task chain.

Regarding each specific task, students might ask themselves: Am I equipped to handle this task? What additional knowledge do I need to address this challenge? Is collaboration with others necessary?

4.3. The Guiding Issues can be a General Task Related to the Learning Objectives of Each Stage

The formulation of guiding issues should strongly align with learning objectives. Such questions need to be grounded in scientific rigor, enabling students to grasp the nuances of relational databases. Through project learning, the goal is to foster an understanding of core database principles and nurture holistic database expertise.

Consider the following examples:

How can we engage with customers in a cordial manner?

What knowledge is essential to grasp the normalization standards of a database?
Which user categories can access specific database information?
What considerations are pivotal when mapping out storage strategies for diverse files within the database?
How can we engineer designs that safeguard data file integrity?
How would you ensure the database remains secure?

4.4. Guiding Issues should be Challenging and Appropriate for Students

Guiding issues should be rooted in students' perspectives, drawing from their experiences. Their complexity needs to strike a balance, not being overly simple yet not surpassing students' current understanding. This ensures that students frame these questions based on their accumulated knowledge. The process of analyzing, recognizing, and decision-making evolves into a methodology for thinking and problem-solving, nurturing their innovation skills and guiding them towards resolutions. Comprehensive guiding issues should span all phases of project-based learning, aiding students in building a cohesive database knowledge structure.

For instance:

In the event of data loss from disk corruption, how would you retrieve and restore the database?
What methods can be employed to oversee and evaluate database performance?
If the database's query efficiency diminishes, how would you enhance its performance?
When users require additional functionalities, what is the strategy for planning and executing a database upgrade?

5. PROCESS EVALUATION

In addressing the pivotal challenges of database design, the learner team independently gathers textual resources like textbooks. They leverage supplementary learning tools offered via the online platform, understand database design methodologies, and select design themes with real-world applications in mind. Through an unceasing exploration of knowledge, learners cultivate independent thought, immerse themselves in the database design and creation process, harness their imagination, and pursue innovative solutions to tangible challenges.

Evaluators for the project-based learning process might include users, instructors, or the students themselves. By evaluating learning outcomes at each database design stage, feedback is offered on design plan inadequacies. This leads to the formulation of focused guiding questions, enabling students to self-learn, refine their plans, and effectively complete project-based learning assignments with both efficiency and quality. It is imperative for students to take the helm of their learning journey in project-based learning. Given the distinct learning goals and outcomes for each database phase, corresponding evaluators and assessment methods are crucial. Post identification of core tasks and learning objectives, educators craft the evaluation method, pinpointing the emphasis and prerequisites in the project-based learning phase. They then communicate these to students, ensuring they grasp the standardized database design expectations [2] (Zhan Ying, 2022).

Evaluation metrics form a vital roadmap for learning. Continuous assessment throughout project-based learning must mirror the learning impact. This is achieved by sequentially assessing subtasks in alignment with learning goals, weighing the content and criteria, and shaping the corresponding evaluations. Assessments encompass students' questioning prowess, analytical skills, comprehension of database's central concepts during the learning curve, and the congruence of the developed database with learning goals and user needs, all while furnishing feedback.

6. Analysis of Project-Based Learning Effects

When contrasting direct teaching with project-based learning using databases as an example, how effective is the latter? Does it foster the development of experts' adept at addressing real-world database issues? Database design operates as a large-scale project learning activity. Assessing the outcomes of database project learning hinges not only on the attainment of the learning objective but also on the quality of the final database produced.

The direct teaching approach was implemented in 2022. Essential supportive learning resources tailored for project-based learning was established, paving the way for the adoption of the project-based active learning methodology in 2023. After a year-long experimental teaching phase, subsequently presented is a comparative analysis of the pre-test outcomes versus the post-test results of the two pedagogical methods. The statistical comparison table of the comprehensive situation of the pre-test results of the database course, as shown in table 1. The statistical comparison table of the comprehensive situation of the post-test results of the database course, as shown in table 2.

Table 1. The statistical comparison table of the comprehensive situation of the pre-test results of the database course.

Class Name	Student ID	Pass Number	Highest Score	Lowest Score	Average Score	Standard Deviation
Experiment Class	45	1	70	0	12	15
Reference Class	48	0	40	0	14	11.9

Table 2. The statistical comparison table of the comprehensive situation of the post-test results of the database course.

Class Name	Student ID	Pass Number	Highest Score	Lowest Score	Average Score	Standard Deviation
Experiment Class	45	42	100	0	81	19
Reference Class	48	41	92	10	69	16.5

The score comparison table clearly shows that the average score of the project-based learning experimental group surpasses that of the reference group. However, the experimental group has a higher standard deviation, indicating more dispersed scores within this group. Subsequently, we will delve into which factors genuinely enhance the learning outcomes in project-based learning. The effect size represents the difference between pre-test and post-test scores. Determining the effect size aids in discerning which instructional and learning factors exert influence.

The formula for calculating the overall effect size is as follows:

Overall Effect Size = (Post-test Mean Score - Pre-test Mean Score) / Distribution (Standard Deviation) Mean

The effect size for each student is the individual effect size. Each student is assumed to contribute equally to the overall variance. The formula for calculating the individual effect size is as follows:

Individual Effect Size = (Individual Post-test Score - Individual Pre-test Score)/Distribution (Standard Deviation) Mean

The larger the value of the effect size, the greater the progress of the students [7]（John Hattie et al.，2015）.

Total effect size and Individual effect size of the experimental class, as shown in table 3.

Table 3. Experimental class effect scale.

Student ID	Pre-test Scores	Post-Test Scores	Individual Effect Size
2035	70	91	1.21
2201	0	93	5.35
2202	0	91	5.23
2203	25	91	3.80
2204	0	88	5.06
2205	25	94	3.94
2206	0	91	5.23
2207	45	97	3.01
2208	21	91	4.01
2209	20	87	3.85
2210	0	91	5.22
2211	20	91	4.08
2212	25	95	4.01
2213	0	89	5.12
2214	0	96	5.50
2215	15	92	4.41
2217	0	95	5.46
2218	5	78	4.22
2219	15	84	3.95
2220	10	87	4.41
2221	45	87	2.42
2222	0	62	3.55
2223	0	0	0.00
2224	20	57	2.11
2225	0	68	3.89
2226	0	10	0.58
2227	0	73	4.22
2228	0	64	3.70
2229	0	95	5.46
2230	0	89	5.12
2231	20	89	3.97
2232	0	85	4.89
2233	25	84	3.41
2234	25	66	2.34

2235	25	78	3.07
2236	0	66	3.81
2237	25	78	3.04
2238	0	84	4.85
2239	0	88	5.06
2240	0	84	4.83
2241	16	76	3.43
2242	20	100	4.60
2243	20	71	2.92
2244	0	95	5.46
2245	0	93	5.35
Lowest Score	0	0	
Highest Score	70	100	
Passing Number	1	42	
A Number	0	18	
Average Score	12	81	
Standard Deviation	15	19	
Average		17	
Total effect size		3.98	

Effect size data cannot be directly linked to specific teaching and learning factors. Our next step is to identify the factors in the data that contribute to the enhancement of the effect size. Notably, 24 students have an individual effect size exceeding 4, representing 53%. Conversely, 7 students have an individual effect size below 3, which is 16% of the total. Within this group, student No. 2035, who is retaking the course, has an individual effect size of 1.21, The subsequent data analysis will exclude the data of this student. The individual effect sizes for students No. 2223 and No. 2226 stand at 0 and 0.58, respectively. A pertinent question arises: why do certain students advance while others do not? The answer might lie in the variances within their academic records. Table 4 details the specific data on learning for the experimental group that utilized supportive learning resources.

Table 4. Learning data of supporting learning resources.

Student ID	Tasks Completed	Video Watch Time	# of online discussions	# of chapter studies	# of face-to-face discussions	# of discussions	Chapter Repetition (chapter learning times/chapter number 77)
2035	66/67	620.1min	17	105	9	1	1.36
2201	39/67	215.4min	17	118	6		1.53
2202	45/67	429.5min	17	137	6		1.78
2203	41/67	376.1min	17	65	6	1	0.84
2204	44/67	304.3min	16	96	4		1.25
2205	50/67	520.0min	15	63	5		0.82
2206	47/67	488.3min	17	204	5		2.65
2207	47/67	537.7min	13	93	6		1.21
2208	50/67	544.2min	17	90	5		1.17
2209	39/67	222.8min	14	78	5		1.01
2210	64/67	271.7min	17	135	3		1.75
2211	48/67	437.1min	16	139	8		1.81
2212	49/67	455.2min	16	88	5		1.14
2213	35/67	251.3min	13	161	5		2.09
2214	53/67	639.9min	16	194	3		2.52
2215	46/67	395.1min	8	90	7		1.17
2217	45/67	422.1min	17	161	6		2.09
2218	38/67	327.4min	12	79	5		1.03
2219	35/67	328.6min	15	128	5		1.66
2220	47/67	724.0min	14	173	4		2.25
2221	62/67	492.4min	12	74	10		0.96
2222	66/67	521.5min	17	130	6		1.69
2223	64/67	614.6min	12	86	6		1.12
2224	66/67	358.2min	1	72	2		0.94
2225	64/67	547.9min	16	92	5		1.19
2226	17/67	168.8min	0	22	3		0.29
2227	40/67	466.2min	14	136	4		1.77
2228	66/67	783.1min	15	156	4	2	2.03
2229	40/67	327.2min	0	41	1		0.53
2230	66/67	647.4min	17	108	4		1.40
2231	28/67	159.9min	15	44	4		0.57
2232	52/67	571.3min	17	195	5		2.53
2233	18/67	225.8min	13	71	4		0.92
2234	23/67	144.8min	0	37	2		0.48
2235	64/67	383.1min	5	103	2		1.34
2236	24/67	118.0min	1	64	3		0.83
2237	49/67	382.9min	15	134	4		1.74
2238	24/67	197.1min	16	65	4		0.84
2239	41/67	402.4min	12	134	4		1.74
2240	64/67	374.8min	16	102	6		1.32
2241	33/67	182.2min	14	67	3		0.87
2242	49/67	453.0min	17	140	8	2	1.82
2243	48/67	235.8min	12	88	2		1.14
2244	39/67	312.3min	13	78	2		1.01
2245	28/67	196.9min	11	71	11		0.92
Average	45.39	389.9min	12.9	104.6	4.72		1.36

From Table 4, we discern the following patterns in student learning data:

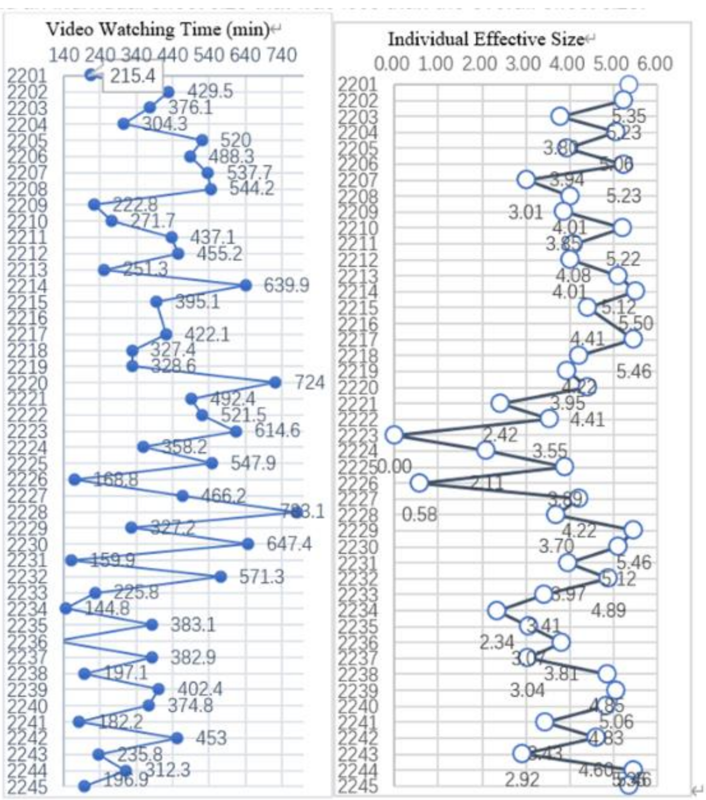

Figure 2. Line chart of video viewing time and individual effect size

For students with a task completion rate below average yet an individual effect size surpassing the overall effect size, the data (student ID, number of tasks completed, individual effect size) is as follows: (2204, 44, 5.23), (2213, 35, 5.12), (2229, 40, 5.46), (2245, 28, 5.35). On the other hand, for students with a task completion rate above average but an individual effect size falling below the overall effect size, the data (student ID, number of tasks completed, individual effect size) is: (2205, 50, 3.80), (2221, 62, 2.42), (2222, 66, 3.55), (2223, 64, 0), (2224, 66, 2.11).

Interestingly, 78% of students fall into two categories: those who completed more tasks than average and had a high individual effect size, and those who completed fewer tasks than average but had an individual effect size that was less than the overall effect size.

From Figure 2, it is evident that there is a weak correlation between the length of video watching and the individual effect size. A notable number of students, even those who watched the video less than the average duration, still attained a significant individual effect. This observation underscores the importance of examining factors beyond video duration, such as chapter learning times.

From Figure 3, we observe that 91% of students exhibit a strong correlation between the number of chapter studies and their individual effect size. However, four students present an anomaly: they studied fewer chapters but still achieved a significant individual effect. The learning data for these students, represented as (student ID, number of chapter studies, individual effect sizes), is as follows: (2229, 41, 5.46), (2238, 64, 4.85), (2244, 88, 5.46), (2245, 71, 5.35).

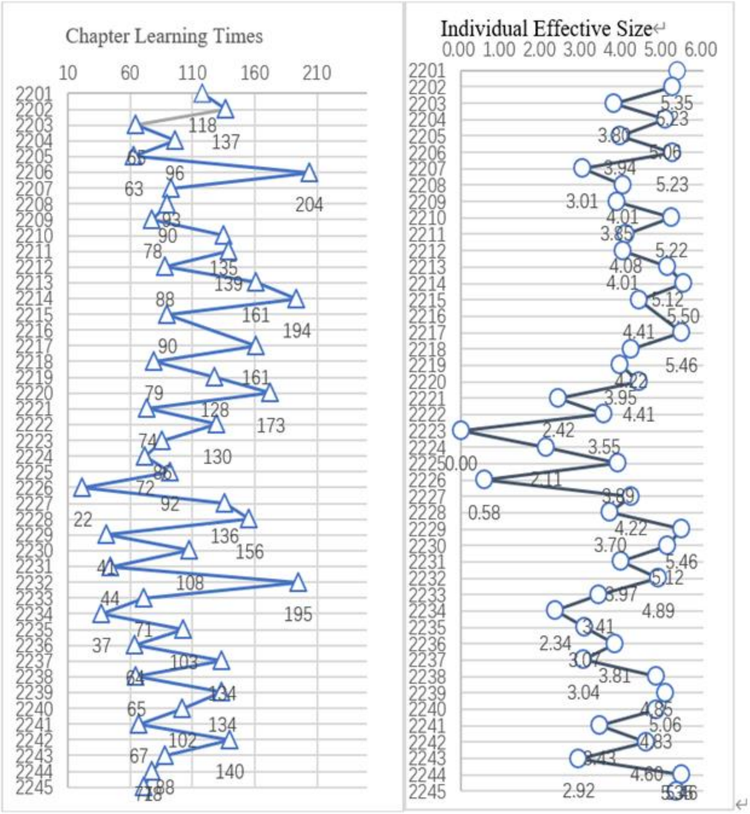

Figure 3. Line chart of chapter learning times and individual effect size

(1) Self-learning attitude and independence

Firstly, examining the use of supportive learning resources, we turn our attention to the overall learning time. Students with an individual effect size surpassing 4 have an average online learning duration of 410.59 minutes, which exceeds the overall average of 389.96 minutes. However, there is an exception with student 2201, whose online learning duration is just 215.4 minutes—below the average. Yet, they achieved an impressive individual effect size of 5.35. Investigations revealed that this student dedicated more time to offline studies. While it is challenging to measure non-online learning durations, surveys offer some insights. It became evident that students with an effect size above 4 generally familiarized themselves with the relevant database knowledge offline, even before their online sessions began. This group also tended to spend more time reading offline textbooks.

Students' active participation in teacher-initiated discussions is another area of interest. These interactions can take two forms. The first is a face-to-face setting where the teacher poses questions and designates students to answer. The second is an online setup where the discussion is teacher-initiated but lacks direct teacher oversight. This gives students ample time for reflection. Notably, among the six students with an individual effect size below 3, half of them seldom engaged in discussions. For instance, student No. 2229 only participated once but still achieved a notable effect size of 5.46. The findings suggest that since discussions were teacher-driven and students were somewhat passive participants, there was not a strong correlation with genuine learning enthusiasm.

Additionally, there were four students who took the initiative to begin discussions. However, their individual outcomes were not notably high. Their primary concerns revolved around basic operational queries, seeking assistance when foundational knowledge was elusive or when they encountered challenges during experiments.

(2) Means to seek help when encountering difficulties

Around 20% of students seek assistance from their teachers, while approximately 50% review the provided supportive learning resources. A mere 2% turn to online inquiries for assistance, and about half delve into textbooks for clarification.

The following list details students with an individual effect size below 3, highlighting the frequency with which they revisited supportive learning resources and their corresponding effect sizes. The format is (student ID, repetition frequency, personal effect size): (2221, 0.96, 2.42), (2223, 1.12, 0), (2224, 0.93, 2.11), (2226, 0.29, 0.58), (2234, 0.48, 2.34), (2243, 1.14, 2.92).

(3) Trend analysis of student learning frequencyof note, among the six students with an effect size below 3, the average frequency of revisiting supportive learning resources is 0.82. Conversely, for the 14 students with an individual effect size above 5, the average frequency is 1.69. This suggests that studying course content without revisiting key materials likely results in a diminished effect size. Consequently, we can deduce that the frequency of revisiting supportive learning resources serves as a significant indicator of students' learning enthusiasm.

(4) The state of creative thinking

Throughout the entire project-based learning experience, no student posed any notably original or innovative questions. During a project-based experiment, a non-standard database design plan was intentionally introduced, and only one student proactively challenged it, presenting his own foundational design ideas.

Among students with an individual effect size exceeding 4, 100% demonstrated the ability to contemplate and provide solutions to foundational guiding problems. However, when faced with more challenging issues, such as improving database query performance in the event of reduced query efficiency, only approximately 10% of the students could offer pertinent solutions.

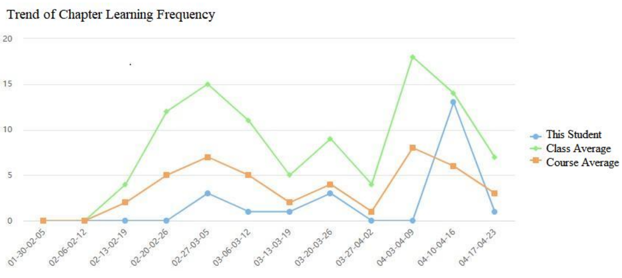

Figure 4. The status of student No. 2226 studying chapters

From Figure 4, it is evident that student No. 2226's engagement with the supportive learning resources was significantly below the average in the initial stages. However, there was a sudden spike in engagement later, with a concentrated learning period lasting as long as 168.8 minutes. Despite this, his individual effect size was a mere 0.58, indicating a pattern suggestive of "cramming" or merely skimming through the content without genuine comprehension.

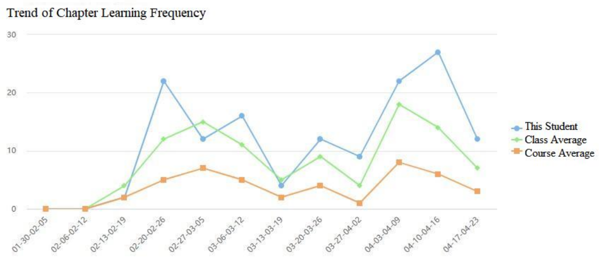

Figure 5. Screenshot of the status of student No. 2211 studying chapters

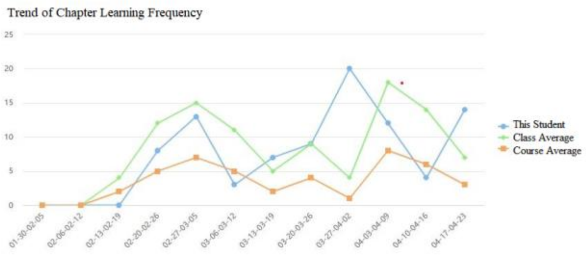

Figure 6. Screenshot of the status of student No. 2215 studying chapters

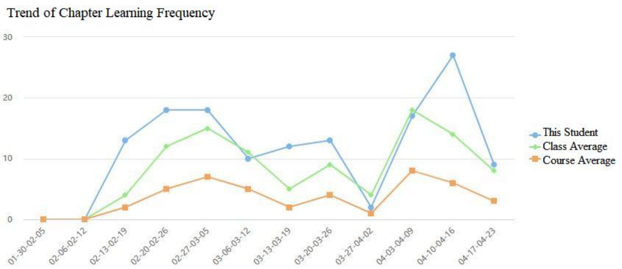

Figure 7. Screenshot of the status of student No. 2242 studying chapters

The online learning time of students with a personal effect size greater than 4 is 100% evenly distributed. Figures 5 to 7 show the learning situation of students with this characteristic. The individual effect sizes are 4.08, 4.41, and 4.60, respectively.
(5) Quality of database results

In database design, when there are three or fewer entities in a real-world scenario, 80% of databases meet the criteria of the 3NF standard. However, as the number of entities rises, the quality of students' database designs tends to decline. This suggests that while students generally grasp database design and management in simple contexts through project-based learning, they require more hands-on experience when it comes to designing and managing databases in more complex situations.

7. SUMMARY OF LEARNING EFFECTS

(1) Strong positive correlation between high-quality project-based learning and student enthusiasm

The "repeat degree of revisiting supportive learning resources" serves as a metric to gauge students' enthusiasm for learning. For those with diminished motivation, this "repeat degree" tends to be on the lower side. Conversely, students who are more invested in project-based learning typically exhibit a higher "repeat degree of revisiting supportive learning resources". Thus, fostering greater interest and enthusiasm in students is pivotal for enhancing their propensity for self-directed learning and independent study.

(2) The influence of guiding issues on learning outcomes

High-quality guiding issues can ignite students' curiosity and thirst for knowledge. The anticipation of results further piques students' interest, prompting them to deeply ponder over the teacher's guiding issues. By encouraging students to venture and explore, teachers can promptly address emerging issues, broadening the scope of understanding.

(3) Does project-based learning outperform traditional remedial instruction in enhancing problem-solving skills?

Owing to students' immersive involvement in project-based learning and the opportunities it provides for independent planning and decision-making, there is a marked improvement in students' initiative to learn. This continuous hands-on experience not only enhances their future planning and decision-making capabilities but also bolsters their collaborative and communicative skills.

Database design encompasses data management and analytical capabilities across diverse practical application scenarios. Through project-based learning, the adeptness to migrate data management and analysis in straightforward scenarios has been substantially augmented.

(4) Efficacy of project-based learning across performance spectrums

Groups fueled by interest and enthusiasm for learning tend to be more effective, in contrast to those with low motivation that show little improvement in learning outcomes. This distinction also sheds light on the broader range of individual effect sizes observed in the experimental class. Given the multitude of learning approaches, the individual effect size emerges as an aggregate reflection of these methods. Enthusiasm and interest in learning stand out as pivotal elements in bolstering students' autonomous learning, self-instruction, and enhancing the effect size. With genuine enthusiasm, project-based learning serves as a potent practical experience, enhancing problem-solving skills and further nurturing a passion for learning. However, for those students deficient in motivation, the impact of this approach falls short when compared to traditional teaching methods.

(5) Classroom dialogue: a facet, not the sole catalyst, of enhanced learning

While classroom dialogue is valuable, it is not the sole method to enhance the learning experience. When students probe and present queries, timely teacher feedback becomes pivotal in fostering their learning journey. As highlighted in Visible Learning, John Hattie (2015) underscores that apt feedback can substantially augment the learning process. When employed judiciously, it facilitates students in comprehension, engagement, and crafting efficacious strategies for information assimilation.

Consequently, as students introspect and deliberate on their unique journeys and insights throughout the project, high-caliber bilateral discussions with educators can catalyze cognitive growth. Such dialogues serve multiple purposes: guidance, assessment, and rectification, all pivotal in bolstering learning.

The intricate design of database project-based learning hinges upon a sequenced task chain characterized by its hierarchy and progression. This spans from initiating queries, leveraging open-ended learning assets, to meticulous multi-faceted evaluation processes. This nuanced, albeit often subtle, pedagogical orchestration by teachers invigorates students. It not only endorses their self-reliance in the educator's role but also spurs them to actively partake in the creation, articulation, and innovation of knowledge, uncovering avenues and essence of self-guided exploration.

Project-based learning is effective in promoting active learning and interdisciplinary STEAM education. Engaging students with project-based learning from primary and secondary schools helps to attract students' interest in interdisciplinary knowledge early and make learning enjoyable. Building interdisciplinary supportive learning resources is encouraged.

Teaching and learning offer no easy shortcuts; they demand an unrelenting cyclical refinement. Given today's information deluge and the swift strides in artificial intelligence, foundational knowledge is readily accessible online. Platforms like ChatGPT have further simplified this knowledge acquisition process. The imperative now shifts towards nurturing students who can navigate beyond basic knowledge points to embrace multidimensional inventive learning. Education transcends mere doctrinarians—it is about kindling the spark of curiosity and instilling a reverence for learning. Once this passion is aflame, it naturally kindles the intrinsic drive to learn, paving the way for boundless ingenuity.

DECLARATION OF CONFLICTING INTERESTS

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
The author(s) received no financial support for the research, authorship, and/or publication of this article.

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